SOME PROPERTIES OF MULTILAYERED PATTERNS (OF INFORMATION): INSIGHTS FROM MEDIEVAL ARCHITECTURE

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The work presented in this poster is an initial attempt to understand how information is organized so as to create order. The focus is on how geometrical forms come together in an integrated way and the kind of properties that facilitate order. The exploration is inspired by medieval art and science, where mathematical and geometrical aspects of order and wholeness were studied and applied to architecture and ornament design. In pursuing the problem of integration and organization of information, we are building on Christopher Alexander's "theory of centers." This theory, which is based on his career-long analysis of medieval architecture, provides a language and a methodology for achieving integration and organization in geometrical forms and architectural spaces. In addition, Alexander's theory describes an evolving continuum for creating coherent spaces and intensifying them with details through what he defines as "structure-preserving transformations."

The pyramid-like framework advocated here for analyzing information organization stems from the observation that there is a stepwise progression in the way signals (from the environment and/or the underlying system) are captured as data, then abstracted in the context of the user's tasks to meaningful representations (e.g., indications and icons) on a display. In domains such as aviation and space flight, the complexity of the underlying systems is such that many components and their corresponding data and information are physically interrelated (e.g., an increase in a chamber's temperature results in an increase in pressure). Presenting these interrelationships by integrating geometrical forms into structures of information is critical for improving users' understanding of current and impending situations. When these structures of information are organized into a whole, emerging patterns are revealed, providing the so called "big picture" that pilots and astronauts strive for.

Nevertheless, creating a visual display that is well integrated and organized is a very difficult task. Projecting a sense of wholeness such that interrelationships become apparent and users can intuitively "understand" the dynamics of the system and be sensitive to anomalies is also quite a challenge. Cockpit display of sub-system information is certainly one area that is in much need for integration and organization, but there is no tradition or theory today to guide designers in creating such "integrated displays." To this end we examine the artifact portrayed in this poster to try and understand how its geometrical elements come together. We then touch on the levels of abstraction, integration, and organization that appear to support the sense of wholeness that emanates from it.

The tilework was constructed sometime between 1304 and 1307 AD and is made from tile, paint, and stucco. It portrays multiple patterns that are woven together to create a complex and highly interconnected visual effect. Using Alexander's theory, three main centers were identified: one is around the dark star, the second is at an intersection of the stucco pattern, and the third is marked by three chevrons-like forms. Around each center revolves at least one "basic polygon" which also defines a grid. When each one of the basic polygons is rotated and/or flipped along the grid, it can generate the entire visual field. The area delineated by the three main centers that were observed is a highly condensed region. It forms a 30°-60°-90° triangle—the smallest polygon capable of generating the field.

In addition to these geometrical properties that lie underneath the revealed picture, the artifact exhibits elements of abstraction, integration, organization, and compression. *Abstraction* can be seen in the way the visual field appears as a constellation of stars or floral formations (or both). *Integration* is evident in the way geometrical forms are woven together around each center; another level of integration exists in the linkages between centers (e.g., the diamond between the dark star-like centers). A hint of *wholeness* appears in the way patterns, which contain elements from different centers (e.g., the figure eight-like racetracks), emerge in a visually coherent and cohesive way. *Compression* exists in the way the entire field can be generated by increasingly small polygons that at first glance appear irrelevant and indistinct.

Several preliminary observations can be drawn from this analysis. First, an intense and highly organized visual field contains several centers that are linked together by means of unique geometrical forms. Second, Alexander's structure-preserving transformation can be observed in each of the three centers, and appears to support the basic polygons that revolve around them. Third, the centers support patterns that crisscross the visual field; some of which are made of elements from distinct centers (e.g., the figure eight racetracks) creating a combined, or integrated, pattern. Fourth, the emergence of multiple patterns and the existence of manifold grids opens the door into the so-called "information spaces." And finally, the artifact's visual field can be condensed within a very small polygon, which contains all the information necessary to generate the whole—an observation which may have implications for the design of future adaptive interfaces that need to be transmitted to remote sites.

To conclude, the research effort described here explores the extensions of Alexander's theory into the realm of information spaces where it becomes feasible to infuse, compact, and visualize interconnections among large amounts of data and information. The intended application of this research is in the design of information systems for aerospace applications such as airline cockpits and NASA's mission control centers. We believe that properties of organization and order that exist in medieval artifacts can be efficiently employed in the presentation of modern information systems, highlighting interrelationships between data points as well as sets of data and information. With further study, it may be possible to generate the kind of information spaces that are inherent in medieval artifacts in order to house large amounts of modern data. We hope that such exploratory studies will also help support the perceptive and intuitive faculty necessary to design the integrated displays of the future.

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